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AN ESSAY

ON THE

Heating and Ventilation

—OF—

PUBLIC BUILDINGS,

WITH SPECIAL REFERENCE TO

The Senate and House of Representatives

OF THE UNITED STATES.

(With Five Illustrations.)

With Compliments from the Author

By J. L. SMITHMEYER, Architect,
F. A. I. A.

WASHINGTON, D. C.
R. O. POLKINHORN & SON, PRINTERS,
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VENTILATION
OF
PUBLIC BUILDINGS.

I.

INTRODUCTORY.

That pure air and an abundance of light are essential to the health and comfort of the human race is universally conceded. Each generation, as it records its testimony and statistics on hygiene, enables its successor to profit by its experience and knowledge, while the discoverers of improved methods of promoting the welfare of their fellow-beings are entitled to high rank in the list of the world's benefactors. Diligent research and reformation in matters pertaining to the proper ventilation and sanitary condition of public schools, theatres, churches, court-rooms, offices, etc., are the order of the day. One of the most important themes of discussion among scientific men in this part of the world is the necessity of improving the ventilation and heating of the halls of Congress and Department buildings.

The defective system of ventilation and the peculiar structural arrangement of the halls of Congress, wedged, as they are, within the surrounding corridors and committee-rooms, are a serious embarrassment to a satisfactory introduction of the essential elements of light and air.

From the Report (No. 1970, June 24th, 1884,) of a Committee of the House of Representatives of the 48th Congress, on "Ventilation and Acoustics of the Hall of Representatives," and from a later report (No. 2026, July 2d, 1884,) by the same committee, it is evident that the defects of the present system of ventilation in this hall are fully recognized. These defects were also well known to the "Board of United States Officers" appointed several years ago for the purpose of investigating the ventilation and heating of the Halls of Congress. This Board was also empowered to execute such recommendations as it made on these subjects, for which purpose an appropriation of $30,000 was recently made by Congress; other appropriations had been previously made from time to time. This Board was again requested by the committee of the last (48th) Congress to suggest other changes in the existing mode of ventilation which would improve its condition, and reported itself "opposed to any material change in the system of ventilation now in use in the Capitol of the United States."

Constant and vigorous complaints of the serious consequences resulting from the impure air and strong drafts of the hall have been renewed by its occupants and will not be silenced by the decision of the Board, which would close the door to health and comfort and rust the hinges of progress.

The report embraces the recommendations of the Architect of the Capitol (page 7, line 40), who is also a member of the "Board of United States Officers," but received the signatures of only two of the seven members of the committee; thus making it a minority report. The regular committee report reads as follows:

> "*The Committee on Ventilation and Acoustics have had under consideration the subject of improving the ventilation of the Hall of the House of Representatives, and beg leave to submit the following report:*
>
> Your committee have given the subject of remedying the defects in the present system of ventilating the House of Representatives their careful attention and investigations, and more particularly for the reason that to the errors in the principle of the present system of ventilation much of the suffering from ill health of the members and occupants of the House may be attributable.
>
> The present system of ventilating the House was adopted over thirty years ago, at the time of the completion of the present Hall of the House of Representatives, and has been continuously in use from that time to the present, and without change in principle, and without the adoption of the later and more advanced knowledge which the science of ventilation has acquired.
>
> At former sessions of Congress since that time many improvements have been suggested and experimental trials had, and many of the best experts and authorities consulted, at great and continuous expense and cost to the Government, with a view of improving the bad condition of the air in the House, but without a change in the principle of the system, all of the past efforts having failed, as the present condition testifies"

In view of the foregoing, it is evident that the present system does not possess the merits claimed for it by its advocates, who have endeavored for a long time and at great expense to make it meet the required demand for proper ventilation.

The object of the present remarks is to point out the defects of the system now in use and to urge the substitution of another which has been extensively tested and has given entire satisfaction wherever fairly tried, since it embraces and utilizes the latest discoveries in hygiene of the sanitary authorities of both hemispheres, viz: Professors Cavarat and Bernard, of the College of France, Dr. Drewitt, lecturer before the Royal Institute of Great Britain, Profs. Tyndall, Huxley, Roberts, Mr. Francis Darwin, Rolle Russell, Sir John Lubbock, Siemens, Price, Dr. Ehrenberg, Prof. Pettenkoffer, Dr. Josef Fodor, Dr. Frankland, Dr. Benjamin Ward Richardson, Dr. Burdon Sanderson, Pasteur, D. F. Winslow, Sir David Brewster, Dr. Frank Hamilton, Dr. Fourcault, Dr. M. G. Ellzey, Dr. Rogers S. Tracy, Sanitary Inspector of New York City, General Arthur Morin, Director of the Conservatory of Arts and Trades, Paris, Col. Warring, Dr. Parker and others.

II.

THE MAIN DEFECTS OF THE SYSTEM NOW IN USE IN THE HALLS OF CONGRESS.

Both Halls of Congress are ventilated by the "Plenum" system, reinforced by pulsion, described as follows:

> "The fresh air is brought in from below through registers in the floor and walls close to the floor; the foul air passes out through escape registers in the ceilings. Its motive power is heat, re-inforced by pulsion."

This pulsion is created by fans or blowers and facilitates the ingress of the air. Hence it is often called the "Pulsion" system. Its faults may be summed up as follows:

I. It does *not ventilate* in the proper sense of the term, *i. e.* does not provide a sufficiency of pure air without causing strong and annoying drafts, and fails to remove the vitiated air before it becomes injurious to health. An atmosphere thus impure retained in a close apartment, in the absence of direct light from the sun and efficient ventilation, becomes impregnated with organic poison and hence a factor in the generation of dangerous and fatal forms of disease.

II. It does not distribute the fresh air equally over the entire horizontal cross-section of the Hall, as it should. (See Report 1970, page 11, line 3.)

The floor of the House of Representatives is occupied by 320 members and about 320 officials,—employes and persons having the privilege of the floor. The perforations, registers, etc., in the floor and walls through which the air enters are, in large measure, covered by the 640 occupants sitting or standing over or against them. There are also 320 desks, a large number of chairs, tables, etc., for stenographers, and the bulky rostrum for the Speaker and clerks. In addition to these obstructions, hundreds of books and papers are scattered over the floor, and many registers have been filled up by members to avoid drafts. Thus an equal distribution of the incoming air is materially interfered with and unpleasant drafts are created here and there over the entire floor of the Hall. Add to this the fact that the conductibility of the glass in the ceiling produces a considerable cooling of the interior layers of air in contact with the glass; this air becoming denser than that below, descends, and is constantly replaced by more, which is likewise cooled. By this continued movement the room thus covered with glass becomes very difficult to warm. Add also the fact that the cold air, which in its descent naturally flows towards the fire-places at the sides of the chamber, produces a draft or drafts the more unpleasant to the occupants of the chamber in proportion as they stand near to these fire-places. A result similar in its consequences occurs when the doors leading into the corridors are opened and air of lower temperature is admitted.

Sir Charles Barry, Architect of the Parliament Building, London, says:

> "It is almost impossible to avoid the inconvenience of partial currents when air is admitted from the floor, or near the person."

III. It introduces "ground-air," which, in respect to the building under discussion, is especially deleterious, since much of it comes from the low grounds on the west of the Capitol, where it has been confined in the interstices of the soil with various substances, whereby its vital qualities have been materially changed without in any sensible respect altering its chemical qualities; in other words, it has become, as Dr. Richardson would say, "devitalized." It is called "ground-air," and is brought to the surface by atmospheric pressure, especially during the fall of the barometer. Possessing greater gravity than atmospheric air, it creeps along the low grounds to the west of the Capitol, 33 feet below the basement floor of the building. This phenomenon is clearly visible on frosty mornings. This air is drawn into the airducts leading into the building by means of fans, which also force it through the heating, moistening and tempering apparatus into the Halls of Legislation. Experience teaches that air from low levels, especialy from *made ground*, and marshy and alluvial soil, is less pure than air introduced from higher levels. It is also well known that deleterious factors which vitiate air are invariably found at or near the surface of the earth. Instead of *descending*, poisonous gases, contagious germs and miasmatic emanations *ascend* when unimprisoned.

> "The idea that miasms, poisons or germs are held in suspense by the air in peculiar localities, must instantly collapse in the face of the fact that atmospheric air moves over the surface of the earth with an average velocity of about eleven feet per second, and that even still air,—whose motion our tactile sense is unable to feel,—travels at the rate of about twenty inches to the second. Hence, any substance present in the air of a given locality must have its source in the soil below, or emanate from an object on the soil, whence it is continually renewed or re-placed," ("Etiology of Zymotic diseases," by Dr. M. A. Rust, of Richmond, Va.)

Physicians and scientists agree that such deadly and impalpable influences lurk near the earth's surface.

IV. The method of supplying fresh and removing foul air is one of the most objectionable features of the system employed in the Capitol; hence the constant protest against the unwholesome atmosphere in the Halls of Congress is not unreasonable. The occupants are compelled to inhale air polluted by previous existence in a low, marshy soil. It becomes still further contaminated by the products of combustion in the basement, and by exhalations from the lungs, emanations from the human body, evaporation from damp clothing, and by cigar stumps, tobacco quids, and expectorations cast upon the heated registers, as well as by the dust that ascends from the floors of the Halls. As this vile compound is forced up by the propelled air from the floor to the ceiling, the occupants must inhale it; consequently many persons have been, and others are being, slowly, though unconsciously, poisoned by this vitiated atmosphere. This is in accordance with the theory of "zymotic disease" as maintained by the medical profession. It is well-known that the organs of respiration are more subtle than those of digestion,—the nourishment supplied to the body being visible to the eye, perceptible to the taste and subject to control; moreover, the effect is immediate. Naturally, therefore, the organs of digestion receive closer attention than those of respiration, so slowly do the latter show the effects of even the most pernicious and deadly causes.

V. The peculiar construction of the wings of the building in which these Halls are, so to speak, coffined, causes a total exclusion of the sun's rays and prevents the admission of fresh air. The influence of sun-light on life and air has ever been the subject of experiment, study and discourse among the world's distinguished *savans*, not one of whom has denied that an abundance of direct light is requisite for the health and comfort of the occupants of a building, while all agree that no amount of artificial or reflected light will compensate for the absence of the direct action of the sun. Moreover, from the earliest periods solar-light and heat have been considered as having a most important bearing on longevity. So impressed were the vigorous Romans with the life-giving qualities imparted by sun-light, that they constructed terraces on their house-tops devoted to the "Solaria," or solar-bath, that their bodies might be exposed to the invigorating, life-imparting influence of this "gift of the Gods."

It is well-known that by a familiar process the atmosphere abstracts the moisture from the organic germs floating therein, rendering them innocuous; also that microscopic organisms cannot subsist in dry. pure, well-lighted air. One of the most important accessories of this process, and one without whose concurrence oxydation only takes place to a very limited extent, is the sun-beam. Air cannot be kept pure in an apartment from which sunlight is excluded. Yet, from our Congressional Halls this benefactor, this preserver of health and purifier of air, is rigidly banished: the sun's rays have never penetrated their walls, and a breath of fresh, unpolluted air from the outer world has never been permitted to enter!

VI. The removal of the impure and introduction of the fresh air, are not, *as they should be*, simultaneous and interdependent. The foul air does not escape from the room in the ratio in which the fresh air enters, and *vice versa*. (See report 1970, page 33, line 9.) As a consequence, the purity of the air varies greatly at different times and different places.

For instance, when the floor and galleries are crowded upon some important occasion, the members on the floor find themselves, in many instances, attacked with nausea and headache, while ladies and others in the galleries, are not unfrequently overcome with fainting fits.

Moreover, it has been clearly demonstrated that continued breathing of vitiated air is productive of one form or another of zymotic disease, though it may be difficult in many instances to trace the disease to its source. The injurious effects of such an atmosphere are more immediately manifest among the occupants of the galleries, since the polluted air is inhaled by them as it approaches the ceiling, and *after it has passed through the lungs of those upon the floor!*

Dr. Richardson says:

> "The air admitted for respiratory purposes should always be pure and as fresh as it can be. Air that is breathed over and over again

is devitalized, and in such air there is not only risk of accumulation of the products of combustion, fumes of gas and odor of decomposing substances, but the air itself is deprived of its full power to vitalize. As a rule, whatever is producing an offensive or oppressive smell, however faint, is doing harm to the air and should be at once removed."

III.

THE VENTILATION OF OTHER GOVERNMENT BUILDINGS.

Injurious to health and comfort as the air in the halls of Congress is, it is incomparably less so than is that in the Department buildings in which the unfortunate and helpless employes of the Government are compelled to remain for seven hours, daily and uninterruptedly. With the exception of the N. and E. wings of the War Department, there is no provision in these buildings for a systematic supply of fresh air; that which enters in winter comes through the cracks of the windows and through the doors during their occasional opening.

Gen'l Arthur Morin, the foremost authority on ventilation and heating, says:

> "Every heating apparatus or system of heating which does not provide in itself for an ample and regular change of air, or which is not connected with suitable arrangements for producing such a change, is injurious to health."

The worst ventilated of the Government buildings is, undoubtedly, the Treasury. Two thousand persons daily occupy this building seven hours, during which period they breathe substantially the same atmosphere at 4 o'clock P. M., that existed on their entrance at 9 A. M., only at the former hour it has become absolutely polluted by the admixture of various deteriorating substances generated during the day, but more especially by repeated inhalation. The certainty of this result is obvious when it is considered that 1,800 cubic feet of fresh air changed six times an hour are required for the preservation of health for in-door life. The amount required *per capita* in seven hours is 12,600 cubic feet, while the actual amount allotted to each occupant of the Treasury Department during this period is 1,436 cubic feet.

The following figures testify to the accuracy of this statement. The available floor space of the structure is, in round numbers, 41,000 square feet; the height of the building is 70 ft. So that 2,870,000 cubic feet is the amount of air this building contains. This, divided by 2,000 (the number of occupants), allots 1,436 cubic feet to each. There being no appreciable supply of fresh air during the seven hours, the air on hand in the morning remains in the rooms all day, as stated, and, being the only medium of respiration, is inhaled over and over again. What the character of this compound is at the close of the day's business, and its effect upon those compelled to breathe it, has been fully described by Drs. Hamilton and Townsend (the latter health officer of the District of Columbia), without, however, receiving any further official attention.

IV.

THE DOWN-DRAFT SYSTEM GENERALLY CONSIDERED.

It is not the purpose in these remarks to enter into detailed descriptions, computations and illustrations of the proper remedy for the evil in question. This has already been done by the writer on previous occasions and in his official capacity as one of the expert architects appointed by Congress, in 1880, to consider the question of the extension of the Capitol for library purposes, and the improvement of the light and air in the Halls of Congress. His report in this connection (No. 753, January 14, 1881), is accompanied by illustrations; and his recommendations to the Committee of the House of Representatives on Ventilation and Acoustics, will be found in Report No. 1970 (June 24, 1884). But he may be permitted to here express the conviction that no system of ventilation for the halls of Congress will give perfect satisfaction, until the upper gallery story of these halls (as shown in the illustrations to his report of 1881) is extended to the outer walls of the building, to the end that they may be flushed with fresh air and sunlight when not occupied.

The English, French and German governments have greatly assisted their architects and sanitary engineers in all experiments and investigations, in order to familiarize them with the laws of hygiene and their practical application. The result has been a general substitution of a newer system of ventilation, embodying the advanced principles of hygiene, diametrically opposed to the old method. This system is called the "vacuum," or "*down-draft*," and consists in exhausting (i. e. *withdrawing*) the vitiated air through perforations in the floor, by means of fans or fires, and in filling the partial vacuum thus created by letting in fresh air through corresponding perforations in the ceiling. By this method the fresh air enters through the ceiling and distributes itself, horizontally and equally, over the highest stratum of the room, and descends in the ratio in which the air beneath is exhausted from the lowest part of the room. In its slow, equal, and constant downward movement (not exceeding 2 cubic feet per second) every space and crevice is filled with fresh air, rendering it impossible for any foul air to remain and be re-inhaled by the occupants; and, since the downward movement of the air extends slowly over the entire horizontal cross-section, all drafts are avoided. The velocity of this movement never varies. The humidity of the air in hot and dry weather, and its temperature, in summer and winter, can be momentarily adjusted and regulated before it enters the room, but the quantity of the incoming fresh air is the same.

A cardinal feature of this system, of the greatest value in public buildings is, that by it *the removal of impure, and the introduction of pure air, is simultaneous and interdependent.* To properly ventilate, the impure air must be removed at the same moment and in the same quantity that the pure air is being brought in. As explanatory: Should the exhaustion of the bad air at the floor be somewhat checked, the suctatorial force upon the air above and about it would be correspondingly reduced, and should it be entirely stopped, the fresh air would stop descending. As a consequence, *the room would not be supplied with fresh cool air in summer, nor with warmed air in winter.* In other words, the removal of the foul air is the *sine qua non* for obtaining fresh (cold or warm) air to breathe. Where there are galleries, these are supplied with separate exhaust-registers, so that no part of the gallery-air can reach the floor of the hall.

Great stress has been laid by the opponents of this system upon the force required to remove the upward tendency of heated air. This force is very small on account of the very slight difference of the gravity between air at zero and air at 70° Fahr. Air expands one four-hundred-and-ninetieth of its volume for every degree (Fahrenheit) of additional temperature. If the temperature of the air in a room is 70° and the outside air is zero, the air in the room will be one-seventh lighter than the outside air; $\frac{70}{490} = \frac{1}{7}$. For example, the Senate Chamber contains 283,490—say 300,000 cubic feet of air; if the air in it has a temperature of 70, each foot of it will weigh 0.0765 pounds (or 13 cubic feet will weigh one pound), making a total of 23,080 pounds. One-seventh of this quantity, or 3,280 pounds, will be the difference in weight between 300,000 cubic feet of air at 70° and 300,000 cubic feet of air at zero, so that the entire (rising) force to overcome is 3,280 pounds, equal to a small fraction of a one-horse power.

The ascending tendency of a balloon containing 300,000 cubic feet of air at 70° F. in an atmosphere of zero would be equalized by 3,280 pounds of weight, and every ounce added to that weight will accelerate its downward movement. Not only hospitals, and buildings of all kinds, but ships of all navies are, at the present day, ventilated by this system, and it is the only one which affords perfect satisfaction when applied to mines of any considerable depth or irregularity of construction.

Dr. Roger S. Tracy, Sanitary Inspector of N. Y. city, says:

> **"As a rule, fresh air should enter a room near the ceiling and foul air be removed near the floor."**

How to bring into a building a supply of fresh air and remove the inside air before it becomes unfit for respiration is purely an engineering question, and it is entirely within the province of the science of engineering to control, with exact precision, the influx, outflow, temperature, relative humidity, rate and direction of the movement of the air within the building. The rate of deterioration of the air and the condition causing such deterioration are questions for the physiologist and chemist. It is as easy to bring the air down through a building 200 ft. or more above the surface of the ground as to bring it 200 yards under ground from a depth of 33 feet below the level of the basement floor. Water, 815 times heavier than air, rises to a height of 32 ft. in an ordinary pump to fill a partial vacuum created by pumping (*i. e.* exhausting the air). The Vacuum Dredging Machine in use on the Potomac River improvements raises 300 cubic yards of water and 300 cubic yards of mud per hour, of which the one is 815 and the other 1500 times heavier than air,—not only raises it from the river ten feet below the level of the fan which creates the vacuum, but carries the discharge quite a distance through a 20 inch pipe.

V.

WHAT HAS BEEN SAID AND DONE WITH REFERENCE TO THE DOWN-DRAFT SYSTEM AT HOME AND ABROAD.

The system under consideration is not new. With every additional discovery in hygiene it has proved its superiority. In his recent professional tour abroad the writer found it in successful operation in many public buildings in England, France and Germany, where it has been in use many years with varying success, according to the understanding by architects or sanitary engineers who have adopted it, of the true principles of hygiene. As early as 1852 it was introduced into several of the English courts, including the Court of Exchequer, and also in the Panopticon in London—a hall 100 feet square by 100 feet high. In 1853–54, a select committee of the House of Lords investigated the subject with a view to adopting this system for their hall. They rendered a full report thereon, from which the following is an extract.

Mr. Goldsworthy Gurney, before this committee, reaffirmed the opinions expressed in his report of 1852, in which he recommended that the system of ventilation in the House of Commons, be changed to the "down-draft," giving the following reasons therefore:

"The true principle of ventilation is to get rid of the emanations of the body from below. The exhalations from which the offensive smells arise are materially heavier than the atmospheric air, and therefore have a very strong disposition to fall; they stick where they fall, and you cannot easily get rid of them. The *down-draft* system will remedy this and get rid of these exhalations as well as the carbonic acid by assisting their natural downward tendency.

The same holds good in regard to the dust rising from the mats and carpets when persons pass over them.

To make this system complete, the air should be allowed to come in entirely at the top and be withdrawn from below at or near the floors.

So complete is this system, that the difference of temperature between *near* the floor and within 18 inches of the ceiling is not of any consequence, as Professor Hann, of King's College, tested.

(?) When hot, foul air is especially lighter, but the change of temperature does not carry against a very slight extraction force, nor does it carry up carbonic acid, the laws of diffusion of gases all interfere against temperature.

The hottest air has a tendency to rise when there is nothing to prevent it.

But even the hottest air will not rise if interfered with by down-drafts, because it becomes immediately mixed with the downward flow.

If all the appertures in the lower part of a room were closed the foul air would fall and remain there. In an absolute still atmosphere a portion would become mixed, under the laws of diffusion, to the point of saturation; there it would rest as a substratum. Generally, when the air comes into a room, it will go out, but in a still atmosphere it will remain, as in the "Black Hole" case of Calcutta:

in this case, the lowest died first; or in cases where persons are kept under hatches many of them have died from the effects of foul air.

In many of the courts thus ventilated we have the power to reverse the order, viz: of bringing the fresh air in at the floor and taking it out at the top; but we have found the down current always more agreeable. The up current is sometimes used, but it is not so pleasing and not so effectual.

So, for instance, in the Court of Exchequer, we have the power of drawing down, or allowing the air to go up. When the court is crowded, if it is drawn down, you can hardly stand in the extracting current, the smell is so disagreeable."

Sir Charles Barry, architect of the Parliament Building, stated that:

> "He always intended the supply of air should be from the ceiling and not from the floor; that it is almost impossible to avoid the inconvenience of partial currents when air is admitted from the floor, or near the person."

Mr. Gurney was intrusted with the work of introducing the down-draft system, as he expounded it before the committee, and it undoubtedly would have produced satisfactory results, had it not been for the insurmountable structural obstacles he encountered. Under the circumstances he was compelled to adopt a mongrel system, composed of both the old and new systems.

Mr. Gurney stated to the committee, upon inquiry, that:

> "The change which he had made in the House of Commons is to admit fresh air freely to the lower parts of the House, and also above the ceiling, etc." Adding: "The fresh air comes in at the second floor below the House and above the roof."

Further, he says:

"About three-fifths of the air is drawn down through the floor, two-fifths is passed up in consequence of the Strangers' Gallery, having no means of withdrawing air from below it. There are no facilities for doing it, therefore we are obliged to draw the air from the Strangers' Gallery through the trellis work into the passage behind, and from thence up into the extracting shaft. All the rest goes downward. Fresh air now comes into the House above; also through the sides under the benches"

Next was Lord Charles J. F. Russel, sergeant-at-arms, who states:

" The ventilation of Mr Gurney is a great improvement upon the previous one. I think there is not that stifled and oppressive feeling which was formerly obtained. The dust rises very much underneath us. There is matting over a perforated iron, through which, even on first coming into the House (although the mats are said to be taken up and dusted every morning) you perceive a great deal of dust rising; and if you put down your foot, or stamp in any way, still more dust rises."

Hon. Ed. S. Cayley remarked:

" The present system of ventilation is much of an improvement over the old one."

From the concurrent testimony of the gentlemen quoted, it is obvious that the "mongrel" system Mr. Gurney was compelled to substitute for the one he advocated is defective in the ratio in which it deviates from the down-draft system proper.

This system of ventilation is very generally understood in France, where it is employed in preference to the old method. It is in successful operation in the Hall of the Corps Legislatif, in the Grand Reading Room of the Bibliotheque Nationale in the Hall of the Institute of France, The Grand

Hall of Trocadero, the Hospital Lariboisiere and many other buildings.

General Arthur Morin, Director of the Conservatory of Arts and Trades, Paris, in his manual, translated by the Smithsonian Institution, 1873–4, remarks (page 332, line 16):

> "It has been shown by the numerous examples that precede, that the establishment of a complete and regular amount of air in occupied places in reality presents no difficulty, and that the rules to be followed are very simple. Their application will be equally so, and will involve but little expense if architects will take care to devise plans for ventilation at the same time they make plans for construction, instead of waiting until the building is almost finished."

On page 321, line 24, in speaking of Halls of Assembly, he says:

> "These places of temporary resort, where there is often more than one person to every square foot of floor surface, should be ventilated at the rate of 1,000 cubic feet an hour to each person."

Adding:

> "The arrangements which I have adopted for the main lecture hall of the Conservatory of Arts and Trades, and of which the satisfactory results have been seen every day for five years, appear to me worthy of imitation.
>
> "The foul air is drawn off through openings in the risers behind the feet of the auditors, and the total clear area for the passage of the air should be calculated, so that the air will only obtain a velocity of 28 or 30 inches a second. This surface should also be distributed as uniformly as possible among the steps. The gallery should terminate in a ventilating chimney, the mean action of which should be determined on the condition that the velocity of the air shall reach five or seven feet a second, in order to secure the permanence of the current; and that it will be well generally, when the construction permits, to make the air flow in through the roof over the lecture room, which should descend into the room through openings uniformly spread over the surface of the ceiling. Large reception rooms and legislative halls should be warmed and ventilated upon the same principle."

He mentioned the following places where the system has been introduced and is in successful operation: Lariboisiere Hospital, Vincennes Hospital, the Palace of Luxembourg, Chamber of Deputies, Conservatory of Arts and Trades, St. Ambrose Infant Asylum, School in the Rue des Petits-Hotels, School of Design, School of St. Martin's Market, the Toulon Lyceum, Glue and Soap Factory, Manufactory of Chloride of Lime, etc.; match factory at Heniexeim, near Antwerp, workshops, cutting works, the Chatellerault Armory, Lying-in Hospital at St. Petersburg, the Chateau Ferriers, Hall of Marshals in the Tuileries, etc.

In Germany it is used in the Imperial Clinic at Potsdam, in the great new Public Hospital in Berlin, the old Parliament (Reichstag) Building, and in other structures in the same city. Recently it was selected by a special scientific commission, presided over by the speaker of the House, as the best and most suitable system for the new Parliament (Reichstag) Building in course of construction in Berlin.

Soon after this Imperial Commission, composed of technical experts and scientists, closed the competition for plans of the new German Parliament building, they invited another for the best method of heating and ventilating that building, and, to induce the participation of experienced architects and engineers, offered the sum of 10,000 marks, divided into three premiums for the three best plans respectively. Eleven plans were submitted, of which the commissioners selected five, finally narrowing the choice to three. The plan of Mr. David Grove, of Berlin, was adjudged the best, and to him was given the first premium of 5,000 marks, and the execution of the work. To each of the other two competitors, whose plans were selected for comparison, 2,500 marks were awarded. It is worthy of notice that all the plans for which premiums were paid contemplated the use of the "*Vacuum, or "down-draft system*" of ventilation. The commission was undoubtedly further induced to select the "*down-draft*" system, for the reason that it had given entire satisfaction, since its introduction into the old German Parliament building, years ago, in spite of the many obstacles that naturally presented themselves in that ancient structure. Copies of the plan adopted by the commission in question, and the programme it issued simultaneously with the invitation for competition, are in the hands of the writer. They evince a thorough understanding of the requirements and a complete knowledge of a proper compliance therewith.

In the United States, this system is employed in a more or less perfect condition in New York City, in the Theological (Episcopal) Seminary and the Ninth National Bank; in Philadelphia, in the Grand Masonic Temple; in the Insane Asylum, at Norristown, Pa.; the Johns Hopkins' Hospital, Baltimore; Soldiers' Home Hospital, Washington, D. C.; and in Brown University Library, Providence, Rhode Island.

In a letter to the writer, the librarian of the last mentioned establishment, Mr. Reuben G. Guild, says:

> "In regard to ventilation, I wish to state that after a trial of five years I am satisfied it is as near perfection as anything of this kind can be. (It is the system you advocate.) At any time of the day a match or taper (burning) applied to the ventilating shaft will be drawn downward. The temperature of the upper third story is precisely that of the lower. This I have verified by a thermometer again and again. As facts are better than theories, should be pleased to have you call and see for your own satisfaction." "The room," he adds, "is octagonal, has galleries, is 78 feet high, and surrounded by a dome."

This "down-draft" system is further, and undoubtedly, extensively, used in both hemispheres, and with great success, especially in recent structures, but those mentioned will suffice to demonstrate its popularity among the designers of monumental buildings.

VI.

THE TWO SYSTEMS CONTRASTED.

The question which is the better method of supplying fresh air to the Halls of Congress,—that now in use, or the one proposed,—should not be difficult to answer in view of the recent discoveries in hygiene, which determine that soil is the principal source of atmospheric deterioration, and that, accordingly, air from low, marshy or alluvial soils is unfit for respiration.

The air in the Halls of Congress is, as already stated, now brought from the low grounds adjacent to the filled-up canal bed, with its multitude of buried carcasses, and the marshy soil of the Botanical Gardens, whose surface, within a very few feet of tide-water, is inundated with every rise of the Potomac. The air thus derived is carried through a damp, dark, underground duct of 200 yards length into the basement of the Capitol. Here it encounters organic odors and vapors arising from cookery, machinery and scullery, the dining-room, bar-room, water-closets, etc., and after mingling with the products of combustion from fires and burning gas, which devitalize the air by producing carbonic-oxyde (inodorous and very poisonous), finally reaches its destination in the halls of legislation. By the method proposed, the air will be drawn from a stratum many feet above the surface of the ground, where it is free from contamination, because not in contact with vitiating matter. It is, hence, a question merely *whether air for inhalation by the people's representatives shall enter the Capitol from polluted sources and be conveyed through deteriorating matter, or whether it shall emanate from a wholesome source and pass through an uncontaminated atmosphere.*

It may be said of the whole class of poisons, contagious miasms, fumes and polluting vapors that devitalize the air and render it dangerous to health and difficult of respiration, that they originate within the soil at or near its surface, and but infrequently rise far above the ground, because with each foot of ascent they are rapidly diluted and attenuated by diffusion, destroyed by oxidation, and rendered imperceptible and innocuous by complete exposure to the influence of light and air. As far as air-analysts know, carbonic anhydride—a natural and normal constituent of the air—does not diminish in relative proportion to its ascent. But from this it must not be inferred that the same is true of emanations from the soil which pollute the air.

Dr. Ellzey says:

> "It does not appear that any definite relation exists between the amount of carbonic acid in the air, or the amount of organic impurities, or the degree of relative humidity, and the prevalence of any known form of disease. It is not, for example, possible for any analyst to determine whether a given sample of air does or does not contain the germs of ague and fever, of yellow fever, of scarlet fever, or of diptheria."

Because there is as much carbonic anhydride at the Dome of the Capitol as at the terrace below, it is absurd to suppose air at a level of the marshes is as salubrious as the atmosphere 200 feet above; that the air which the workman on the Potomac flats inhales is as salubrious as that inhaled by the workman at the top of the Washington Monument (550 feet). Such theory is contrary to all experience, and at variance with every known fact. It would be unwise to maintain that the present imperfect analysis of air can furnish data that will determine which of two samples of out-door air is the more salubrious and fit for respiration. It must be apparent that air coming from a malarious soil and contaminated by ground air during its passage through a long duct (scarcely differing from an ordinary sewer), and devitalized by the products of combustion from gas, etc., is less fitted for respiration than air proceeding from a high stratum.

Simultaneous with the investigation by the House of Lords in England, heretofore referred to, the consideration of a suitable system of warming and ventilating the new Halls of Congress of the United States, then in course of erection, engaged the attention of those in charge of the work. That distinguished officer of the U. S. Engineer Corps, Captain (now General) M. C. Meigs was the first, as early as 1853, to advocate the adoption of a system which brings fresh air into a room through perforations in the ceiling and removes foul air through perforations in the floor.

He says, Senate Doc. I., 33d Congress, First Session, Vol. 2, page 83, Line 22:

> "The common mode of warming and ventilating public rooms is fatal to perfection of hearing.
>
> One or several columns of intensely heated air are introduced through holes in the floor. Being much warmer than the air of the apartment, they immediately rise to the ceiling. If the exit apertures for foul air are above, this fresh and heated air alone escapes, having done nothing for the apartment except to cause whirls and currents, such as we see in a column of smoke passing from a chimney on a calm day. The irregular refraction of sound through these currents of unequal density tends greatly to produce confusion.
>
> If the exits for foul air are below, the hot air accumulates at the top of the room, and, gradually displacing the cooler air, forces it out through these passages.
>
> Professor Reid relates that he has found the air near the ceiling of a room at the boiling temperature, while those on the floor were complaining of cold.
>
> Here we have strata of different densities and unequal refractive power, and hence confusion of sound.

As the warm air must ascend to the top of the room, I propose to let it do so in a large trunk outside of the apartment, pass into a space above the ceiling, and thence by numerous holes find its way, as through a sieve, into the room.

By a steam driven fan, or other mechanical means, we can pump air, in any desired quantity, into any spot to which we choose to direct it.

I would drive all the air required for the supply of the room through a maze of hot-water pipes, raising the whole of it to the temperature required—60° or 80°, as the case might be.

If the room be 30 feet in height, and it be desired to change all the air in it every fifteen minutes, enough air should be pumped in above to cause a general descent of the whole body of the room at the rate of two feet a minute.*

This would be an imperceptible current. The exit should be by numerous holes in the floors, perhaps through the carpet, or the risers of the platforms on which are the members' chairs.

Three important advantages would thus be gained, the avoidance of all eddies, a nearly homogenious and tranquil atmosphere, and the immediate removal downwards of any dust from the carpets, which would thus be prevented from rising, to be inhaled into the lungs.

To prevent the disturbance and contamination of the atmosphere by the gas-lights, I would place them above the glass of the skylights —the space between those in the ceiling and those in the roof being separated from the chamber into which the fresh air should be admitted.

In summer the same apparatus which sends in warm air in winter would supply a constant breeze, and if the temperature of the external air was too high it might be cooled by jets of water from pipes in the air passages, or even by melting ice.

To recapitulate, then, I propose to place the ceiling at such a height as to be within the limit of perceptibility, and thus strengthen the voice; to destroy reverberation between the ceiling and the floor, by a thick carpet on the latter; to prevent echoes from the walls, by drapery; from the chairs and desks, by cushioning or covering them; to keep out extraneous sounds, by making the room and interior apartment lighted only from above; to secure a tranquil atmosphere, uniform in its density and refraction of sound, by excluding all currents of hot or cold air; *to secure a constant supply of pure air at the temperature desired for the room, by mechanical means introducing the air through all parts of the ceiling, and taking it out through all parts of the floor. Thus also to remove dust; to prevent all interference with ven-*

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tilation by the lights at night, by placing them outside the room above the skylights.

I feel confident that; by observing the above-described precautions, we will obtain rooms as near perfection as is possible—*rooms in which no vitiated air shall injure the health of the Legislators, and in which the voice from each member's desk shall be easily made audible in all parts of the room.*

This was the problem to me for solution.

In conclusion, I have the honor to repeat the request made verbally, some days since, that the above notes and observations may be submitted to some person of scientific reputation, the weight of whose authority may sustain me if I am right, or correct me if wrong.

Respectfully submitted to the Hon. Jefferson Davis, Secretary of War, by his obedient servant,

"M. C. MEIGS,
"*Captain of Engineers in Charge of Exten. of U. S. Capitol and Wash. Aqueduct.*"
"May, 1853."

This system was matured by Capt. Meigs with the assistance of the then architect of the Capitol extension, Mr. Thomas U. Walter, LL. D., (now president of the American Institution of Architects,) who also prepared the plans for its arrangement. Not content with his own judgment as to the adaptability of this down-draft method, Capt. Meigs requested Mr. Jefferson Davis (then Secretary of War) to submit *his* (Capt. Meigs') *notes and observations* on the subject to some person of scientific reputation, the weight of whose authority might sustain him if right, or correct him if wrong. The Secretary of War, in reply, stated that he was directed by the President of the United States to request Professor A. D. Bache, LL. D., Superintendent of the Coast Survey, and Professor Joseph Henry, LL. D., Secretary of the Smithsonian Institution, to give the subject consideration, and to make such remarks upon it as they might think proper.

After visiting Philadelphia, New York and Boston in company with Capt. Meigs, these gentlemen made a report to the Secretary of War, June 24th, 1853, in the following words: (p. 85–6, Ex. Doc. H. of R.)

SIR: The undersigned have examined, as you requested, the principles proposed by Capt. M. C. Meigs, of the Corps of Engineers, with reference to the acoustics, heating and ventilation of the Hall of Representatives, to be erected in the Capitol extension building, and the plans which have been prepared by Mr. Walter (Architect) in accordance therewith.

They have also visited, with Capt. Meigs, many of the principle buildings in Philadelphia, New York and Boston, and have examined them in reference to their acoustic qualities.— They propose to make a full report to you on that subject, with a descriptive memoir by Capt. Meigs, and to continue their experiments upon points of detail not definitely settled in their judgment. They are now prepared to report that the principles presented to them by Capt. Meigs are correct, and that they are judiciously applied. They are of opinion that the plans should be provisionally adopted, in order that the building may not be delayed, subject to such modifications in the details as may result from the further study of them by Capt. Meigs, or from the experiments and observations of the commission.

This general adoption of the plans will not, it is believed, interfere with any changes of details likely to be found desirable.

Very respectfully, yours

HON. JEFFERSON DAVIS, A. D. BACHE.
Secretary of War. JOSEPH HENRY.

In view of the above, it will be asked why was the experiment not tried?

The answer to this question will be readily discovered by a careful reading of that part of the Meigs report, found on page 83, line 22, of Sen. Doc. 1, 33d Congress, Vol. 2, 1853:

"By a steam-driven fan or other mechanical means we can pump air in any desired quantity to any spot to which we choose to drive it.” And line 51, same page, “If the room be 30 ft. in height, and it be desired to change all the air in it every 15 minutes, enough air should be pumped in *above* to cause a general descent of the whole body of air in the room at the rate of 2 ft. a minute.” ([redacted]

From the above it appears that the expected success of the system depended upon the action of a blast-fan arranged above the ceiling of the hall to be ventilated, and the “pulsion” force of said fan was expected to force fresh air downward into the hall, carrying before it the foul air contained in the space to be ventilated, and ejecting it finally through perforations in the floor. To a scientific mind, it will readily appear that this process was absolutely faulty in the use of the blast-fan or blower, and that success, instead of failure, would have ensued had an exhaust-fan been substituted for the blast, in which case the fan must, of course, have been placed below the floor, and the foul air drawn out by what is commonly termed suction, thus at the same time creating a vacuum or partial vacuum in the space from which the foul air was drawn, which under natural laws would immediately have been filled by the ingress of pure air from above, and the continual action of the exhaust-fan would necessarily have produced a continuous circulation of pure air through the space to be ventilated. While under some circumstances a blast-fan and an exhaust-fan might be considered equivalents of each other in certain mechanical processes, it will be very apparent that for the purposes in question these devices are not mechanical equivalents, and differ from each other in a measure best expressed by the difference between failure and success. In the case of the blast-fan, it will be seen that the pure air from above is *forced* down upon strata of foul air, which is compressed to a greater or less degree and serves as an elastic cushion, the reacting force of which has a tendency under the resolution of forces to project the pure air laterally or to hold it in suspension, while the pulsion of the pure air forces the foul air down into the space occupied by an audience or congregation of persons in the room. In other words there can be had no absolute control of the foul air, while in the case of the exhaust-fan it is apparent that a vacuum is created immediately below the foul air, and the latter will, *unimpeded*, rush to such vacuum, and in so doing exhaust the space above, which in turn will be filled by pure air under the same natural laws.

It is a source of deep regret that the views of the Board of United States Officers, referred to in the introduction to this pamphlet, are so greatly at variance with the opinions and conclusions of those eminent authorities to whom reference has been made, and more especially in view of the fact that the names of Darwin, Huxley, Tyndall, Pasteur, Pettenkoffer, Fodor, Cavarat, Drewitt, Frankland, Ehrenberg, Vogt, Hamilton, Richardson, Ellzey, Winslow, Coues, Warring, Morin, etc., and their productions are more familiar to the world than those of the Board of United States Officers.

The superiority of the vacuum or *down-draft* system was, however, admitted by one member of this Board; but, not being acquainted with the science of engineering, he conjectured some draw-back and on the strength of this he opposed its adoption. He says:

> "Taking the air from the level of the floor, or near the level, is a very desirable way of doing it in many conditions. It is a very good thing in a hospital. One of the best ventilated hospitals that I know is one that I planned, and which was constructed at Soldier's Home, Washington, D. C. The ventilation is down through the floor in winter, and upwards in summer." This gentleman adds: "The same system is adopted in a hospital being built now in Baltimore (*i. e.*, Johns Hopkins) It affects a saving of fuel, and a good distribution of the air." (Report No. 1970, page 25, line 45)

Could there be a better endorsement of the efficiency and economy of this system? Is it not also rational to conclude that a system which gives satisfactory results in a hospital, where, of all places, the occupants are most sensitive to drafts, humidity of the air, and sudden changes of the temperature, must be preferable to one calculated to make the healthy sick? The fact that the *down-draft* system introduces *pure* instead of *polluted* air, and effects a thorough distribution of the pure air as well as a timely exhaustion of the inside air before it becomes injurious to the health of the occupants, characterizes it as a superior one. Notwithstanding this, however, and the many evident advantages of the vacuum system evident over the old method, which make the former especially desirable for large and crowded rooms, the gentleman, in question, proceeds thus:

"But the difficulty in the way of doing that, in the case of large rooms almost entirely covered by people is so great as to make it undesirable."

There is evidently a lack of harmony between the statements of the Board of United States officers, as a *body*, and those of two of its members, on the question whether this (down-draft) system of ventilation was ever experimentally tried in the hall of the House of Representatives. The unanimous report of the Board declares that it was tried (Report 2026, page 5, line 26); yet two members of this board state that there had been no trial! One of these gentlemen, on being asked by Mr. Green, of the Congressional Committee, if an experimental trial had been had, replied that this system had *not been tried experimentally* (Report 1970, page 15, line 69), while the other gentleman remarked that he should be very glad to see the experiment of the down-draft system of ventilation tried; adding, I cannot conscientiously advise it, but I think it would be quite interesting to have it tried.

During the entire investigation, which extended over both sessions of the 48th Congress, there was no mention made of an *experimental* trial of the system in the Hall. If such trial took place, where are the records? When and by whom was it made, and under what auspices, and what are the authenticated results? Nothing is known of an experimental trial further than the mention in the report of the Board, which is as follows:

"The Board has the honor to report that, in accordance with the request of the Committee on Ventilation, it has examined the plans submitted by T. C. Perry for the improvement of the ventilation of the Hall of the House of Representatives.

It is the opinion of the Board that if these plans were carried out the ventilation of the Hall would not be as good as it is at present. Ventilation by aspiration has been tried in the Hall before, and with unsatisfactory results.

The Board does not think that downward ventilation would give good results in the Hall."

The cause of the unsatisfactory results of the trial—granting there was a trial—consists in the wrong application of the appliances necessary to carry out this system. In other words, the attempt was made to produce by pulsion what can only be effected by suction, or exhaustion.

Were the steam-driven fan placed under the floor of the hall, to act as an exhaust, creating a partial vacuum, and not above the ceiling, to act as a pulsion, compressing the air in the room, the result would undoubtedly have been satisfactory.

VII.

HYGIENE AND ARCHITECTURE.

Professors Cavarat and Bernard, of the College of France, have proved the existence of organic poison in crowded and illy-ventilated rooms, and have demonstrated that this poison (in concentrated form) is as deadly in its effects as the noted "vourali," or poison of the viper. If this organic poison, in connection with products of combustion, respiration and bodily emanations, should be unduly retained in a close apartment in the absence of efficient ventilation and direct light from the sun, it must prove injurious to the health and develop some dangerous or fatal form of disease. Great stress should be laid upon the fact that air, even moderately vitiated, if inhaled for a long time daily, produces serious results. The indications are pale face, loss of appetite, depressed spirits and enervation, and bronchitis, phthisis, consumption, and other zymotic diseases, which if not *always* caused by breathing impure air are certainly accelerated thereby. The authorities mentioned declare that this organic poison accumulates largely in all crowded places, and is the deadly Upas of the school room, church, theatre, lecture-room, etc.

Dr. Drewitt, in his lecture before the Royal Institute of Great Britain, stated that *close bed-room air* was an efficient cause for scrofula and consumption, and enumerated thirteen contagious diseases as evidence.

Prof. Cavarat has exposed certain small animals to this poison, which resulted in the slow but ultimate destruction of each.

The detrimental effects of the bad air in the Halls of Congress, especially during the heated term and night sessions (with 1500 gas burners in active operation), may be imagined.

Nor is it easy to destroy this organic poison, or rid the air of its contaminating qualities. Prof. Tyndall states, in an article in "Nature" on Germs, that some of these organisms are indestructible in boiling water or hot oil, and a temperature of 200° Fahrenheit, in dry state, will not destroy them.

Dr. Frankland, in his remarks to the Chemical Society at the Burlington House, said:

> "Of all kinds of organic matter that which is organized and living opposes by far the greatest obstacle to oxydation.

The researches of Chauveau, Burdon, Sanderson, Klein and others, leave scarcely room for doubt that the specific poison which produces zymotic diseases, consists of organized and living organic matter, and it is now certain that air and water are the media of their propagation.

Dr. Frankland says:

> "These germs are invisible to the naked eye, and scarcely perceptible through the microscope, but their rapidity of development and tenacity of life are wonderful."

The experiments of Dr. Roberts with germ life, participated in by Mr. Francis Darwin, Mr. Russell, Sir John Lubbock, *et al.*, prove that these germs form groups, or clouds, that float through the atmosphere. Dr. Ehrenberg testifies on this point:

> "One might properly conclude that clouds of these little germs are floating in the atmosphere, alternating with spaces perfectly pure."

Presumably there are harmless germs and others that are destructive to animal creation just as there are harmless and dangerous insects, reptiles, fishes, birds, etc. Clouds of harmless germs may float by without producing injurious effects, while other clouds of dangerous germs may cause death and destruction in the form of diptheria, scarlet and typhoid fevers, etc., and under certain conditions, yellow fever, cholera, etc.

Science declares the existence of noxious germs, while experience teaches their baleful influence.

Dr. Vogt says:

> "Air is most infected with germs of disease when, through the decrease or increase of atmospheric pressure (according to the law of physics) the ground-air passes from the soil into the atmospheric air, which occurs particularly during the fall of the barometer. This condition" he adds. "is most favorable to typhus fever."

It has been discovered that air confined in soil undergoes a deteriorating process, and that atmospheric air does not stop at the surface of the ground, but penetrates its depths and assists in decomposing organic matter. This "*ground-air*" differs from atmospheric air in that it contains from 10 to 100 times the number of germs and amount of carbonic acid, and is also devitalized. Low, marshy and alluvial soils have large quantities of organic matter in high state of decomposition, ready to be brought to the surface at the slightest instigation.

Dr. Fodor in his recent work, "Air, Soil and Water," asserts that this ground-air fluctuates during the seasons of the year: that the difference in the temperature between the in and out-door air determines the quantity which enters our buildings from below, and that the same natural forces which bring it from the depths to the surface of the soil also drive it into our houses.

"In the winter, spring and autumn months," writes Dr. Pettenkoffer, "and during the night in summer, the air in our houses is warmer than that contained in the soil beneath. The house acts like a suction pump in such cases, absorbing the air within the soil already infected with poisonous gases and germs."

An explanation of the prevalence in cities of epidemic diseases, such as diptheria and scarlet fever, during the winter months, when air is supposed to be perfectly pure, is furnished by this simple induction.

One of the subjects extensively discussed by the International Sanitary Congress, in Geneva, Switzerland, two years ago, was the ventilation of dwelling houses and public buildings. During the session of this Congress it was stated that in large cities it is not sufficient for the purposes of health that external air should be fully introduced into sleeping and living rooms, but that the *upper strata* of the atmosphere should be tapped for the purpose, as the strata near and upon the surface are constantly loaded with matter that should not be admitted to our lungs. In large and densely populated cities, as New York, Paris, London, etc., it is a common remark among medical men that the basement and parlor floors should never be used as sleeping rooms.

Dr. Frank Hamilton, in a paper read before the New York Academy of Medicine, asserts that in a large number of cases of scarlet fever, diptheria, typhoid fever, and other malarial fevers which occurred in New York, Philadelphia, and various cities of the United States, the spread of the infection or contagion could be traced directly to the suctatorial action exerted by dwelling-houses on the soil beneath, which is polluted with gases, sewage-matters and organisms of decay. The same authority asserts that the air lying nearest the surface of the earth is always, and in large cities especially, laden with carbonic acid and other matters of decay, as sulphureted and carbonated hydrogen and sulpho-hydrate of ammonia, together with minutely-divided particles of living-matter which are capable of generating disease. He further says: "The soil to a considerable depth must be regarded as a perfect nursery of microscopic forms of life, constantly laden with these impurities, and by suction exerted by the current of air in contact with the surface, this ground air, with its myriads of organisms, and its deleterious gases is constantly exhumed."

The following is an extract from the report of the board of medical gentlemen appointed by ex-Surgeon General Wales, U. S. N., to examine the soil of the site for a new Naval Observatory in Washington, D. C., said board consisting of Medical Director J. M. Brown, Surgeon J. H. Kidder, and Passed Assistant Surgeon S. H. Griffiths:

"Extended observations have been made by the Board upon the composition of the GROUND-AIR—a department of sanitary surveys, which has not received a great deal of attention hitherto. Whenever water does not stand, as GROUND-WATER, the interstices of the soil are occupied by air, and as the GROUND-WATER rises, this air is forced up into cellars and basements, and becomes, by aspiration into the warmer parts above, the air of our houses. Should the soil contain tracts impregnated with decomposing organic matter covered over by innocuous earth, as is often the case with made lands, air charged with offensive or deleterious organisms is likely to be forced up, in this way, from considerable depths, and may account for the occasional occurance of epidemics which cannot otherwise be explained."

Dr. Rogers S. Tracy, Sanitary Inspector of New York City, in speaking of ground-air, says:

"It contains a large portion of carbonic acid, and frequently organic decomposition. Damp soil is very unhealthy. Water in the ground less than five feet from the surface is unhealthy, and a fluctuating level, especially if the changes are sudden and violent, are unhealthy."

There is another important agent, without whose presence no air is healthy, viz: Light.

Dr. Fourcault affirms that—

"Where life is prolonged, perhaps to the average term, the evil effects of the want of light are seen in stinted forms and general deterioration of the human race."

Dr. Forbes Winslow, in "Light and its Influence on Life and Health," says:

"It may be enunciated as an indisputable axiom, that all who live and pursue their calling in situations where only the minimum degree of light is permitted to penetrate, suffer seriously in bodily and mental health, and that where light is not permitted to penetrate there are found in the highest state of manifestation bodily deformities, intellectual deterioration, crime, disease, early and, often sudden, death. A material as well as a moral etiolation, or blanching, occurs when the vital stimulus of light is withdrawn."

Sir David Brewster says:

"If the light of day contributes to the development of the human form, and lends its aid to art and nature in the cure of disease, it becomes a personal and national duty to construct our dwelling-houses, schools, workshops, factories, churches, cities, towns and villages upon such principles and in such styles of architecture as will allow the life-giving element to have the fullest and freest entrance, and to chase from every crypt, nook, and corner, the elements of uncleanliness and corruption which have a vested interest in darkness."

Florence Nightingale in her "Notes on Nursing," remarks:

> "It is a curious thing to observe how almost all patients lie with their faces towards the light; a patient will even complain that it gives him pain lying on that side. Then why does he lie on that side? *He* does not know, but *we* do. It is because it is the side towards the window."

"The genial glow of the sun's rays," says Mr. Leeds—

> "Makes all vegetation grow, and sustains all animal life; it tempers the icy winds and raises the waves of the ocean into misty vapors which gently descend again upon the earth. These golden rays move and purify the atmosphere in mild currents, and thereby cheer the healthy and heal the sick!"

And yet this great benefactor of mankind is kept from entering the Halls of our National Legislature, and exerting his beneficent influence upon their occupants!

These are the opinions and conclusions of the best-known authorities on hygiene, and of scientists who devote their lives to subjects relating to this science, closely observing every experiment in connection therewith, and disinterestedly and conscientiously giving to the world the results of their observations and experiments.

It is the duty of the architect to be conscientious in every branch of his profession, and certainly that which applies to the prevention of sickness and preservation of health and life is the most important. He should therefore inform himself of all progress in the line of hygiene, that he may be enabled to use the most approved sanitary arrangements in the construction of buildings entrusted to his charge and, by argument and fact, convince and instruct his client, and protect him from the suffering consequent upon the transgression of the immutable laws of nature. Herein the architect has an important mission to fulfil. In the way of *prevention*, he has more to do with the public health than the physician, who is generally called upon to *cure*, rather than to *prevent* disease.

Philibert de l'Orme, who built the Chateau of Anet, and left the mark of his genius upon the palace of the Tuilleries, and who also erected many charming residences at Lyons, and conceived the monument of Francis I. at St. Denis, says, on this subject:

> "I have always been of the opinion that it would be much better for the architect rather to devote himself to ascertaining and putting in practice the best means of preserving the health and comfort of mankind, than to pre-occupy himself with the decoration of walls:" adding, "pray observe that for the lack of proper arrangements, dispositions and accommodations in a house, its occupants are made sick in body and mind, and subject to all sorts of discomforts and inconveniences which they often cannot account for."

These are the conclusions of an honest and truthful man, and a great authority in his profession, and should be respected and adopted by architects throughout the universe.

VIII.

THE QUESTION, &C., STATED.

The requirements of an effective and economical system of ventilating, consist:

1st. In supplying the necessary quantity of fresh air—not less than 1800 cubic feet per person per hour, without creating a draft, and in removing the inside air before it becomes injurious to health, by changing it not fewer than six times an hour for ordinary occasions.

2nd. In removing the fresh and introducing the bad air simultaneously and interdependently, whereby the quantity of entering air will depend upon the quantity of exhausted air, and *vice versa*.

3rd. In bringing the pure air into the room through the ceiling and removing the impure air through the floor.

4th. In distributing the incoming air equally over the entire cross-section of the room.

5th. In bringing the supply of out-door air down from the highest stratum practicable to attain, and in avoiding the introduction of or the mingling with air from low grounds and the products from combustion of gas-burners, etc.

6th. In admitting fresh air and sun-light to the room when unoccupied, to effect which in the Halls of Congress these should either be extended to the outer openings of the walls, which are pierced with windows, or the ceiling should be raised above the surrounding corridors and rooms for that purpose.

But it may be objected; though the above suggestions may contain a complete scheme for ventilating the Halls of Congress, yet nothing is said about heating. How will you manage to operate your plan of down-draft ventilation in cold weather, when in addition to fresh air you must introduce warmth? I have before explained my views on this subject to a Committee of Congress (see Rep. 1970, 49th Con., 1st Sess., p. 9). In brief, they are as follows: The Halls of Congress should be heated by means of air passed over tubes filled with steam or hot water. These tubes should be located in the parts of the attic-story lying adjacent to the ceilings of the two Halls. The steam and heat in the hot water would then be generated in boilers in the basement of the two wings, and carried by pipes to the coils in the attic. The fresh air brought in winter, as in summer, from the Dome of the Capitol, or some other suitable high spot, by means of ducts, as heretofore described, will then pass over and through the coils before being brought under the influence of the suction system below. In this manner we shall have cool, fresh air brought into the chambers from the neighborhood of the Dome in summer, while in winter, by the simple device of heating the apparatus in the attic, we shall have warm, fresh air introduced into the chambers. Plate No. 3 attached to this pamphlet gives a full illustration of my idea on this subject.

IX.

DESCRIPTION OF PLANS ATTACHED TO PAMPHLET.

Plates Nos. 1 and 2 illustrate the effects of the present mode of ventilating and heating the Halls of the Senate and that of the House of Representatives respectively, with special reference to the influence of the glass ceilings and doors upon the incoming warm air, and also with reference to the location of *the out-door levels* of the ingress of the ventilating air (33 feet below the basement of the House wing and 22 feet below that of the Senate wing.) Plate No. 3 illustrates the possible out-door level for the supply of the ventilating air for these Halls (*i. e.*, in an altitude 202 feet above the highest ground surrounding the building); and also the mode of cleansing, moistening and warming the incoming air and of withdrawing it by the contemplated system after it has become vitiated. Plate No. 4 shows the manner of conveying the fresh air to the tempering, cleaning, warming, &c. chamber, and ultimately to the Halls; and Plate No. 5, the adaptation of the system, by commission, to the new Parliament (Reichstag) building in the course of erection in Berlin, Germany, from the "*Centralblatt der Bauverwaltung,*" Berlin, May 31, 1884 (official).

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